Geothermal Energy Use, Country Update for Macedonia

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ABSTRACT

There are minimal changes in the overall geothermal status in Macedonia, which comprise: introduction of one bigger (60 l/s – 75ºC) and several small boreholes (5 – 15 l/s, 30 – 55ºC), completion of the injection system for 1/3 of effluent water, application of heat exchanger (doublet system) for indirect utilization of the geothermal water in the district heating system of Kocani; finalization of the privatization process of existing spas; reconstruction of the heating installations in Negorci Spa and reconstruction in progress in Bansko Spa. Meanwhile, no new research and exploration activities have been performed. Nevertheless, it could be observed increased interest of small investors. About ten exploration concessions have been issued and initial steps of their organization are in progress. Also, there is an enhanced interest for power generation potential, but so far due to the available data and absence of state financial incentives, no any progress could be observed. On the other hand, the existing tariff system for heat supply of geothermal origin is still valid, even though it had clearly indicated that it has no positive influence to the development of this renewable resource. Such tariff system imposes artificial decrease of the selling price, while the development component is not included at all. The ground source heat pump systems have gone through the inexperienced period and nowadays are becoming more and more popular, although there are no any regulative or control mechanisms. The data concerning GSHP are by no means collected and registered.

This country update for Macedonia gives summary of the geological background, known hydro-geothermal resources and their potential, present state of geothermal surveys & utilization and main projects' characteristics, with identification and comments on the possibilities to overcome negatively influencing factors.

1. INTRODUCTION

Macedonia had been one of the leading European countries in geothermal direct uses development during the 1980s. Even rather modest, the state investments in geothermal explorations gave opportunity to the scientists and economy sector to develop three successful big and several small geothermal projects. However, when positive influence had began to give results, i.e. when state planned some new larger investments, political and economy transition process from the beginning of 1990s resulted in a complete collapse of the state economy and, consequently with lost of interest for any further investments in the geothermal energy development. Even more, due to the collapse of the heat users, some of the existing projects have been abandoned.

In the present state policy, in context of geothermal development, this resource has marginal or no relevance at all. Even under pressure of EU to define a consistent policy and strategy for sustainable exploitation of all renewable energy sources in order to achieve defined targets until 2020, government continues to neglect the problem. Existing rare projects and activities are boosted by different EU agencies, developed EU countries and individual efforts. "Energy Development Strategy for Republic of Macedonia up to 2030" and "Strategy for exploitation of Renewable Energy Sources in Republic of Macedonia up to 2020", prepared by the Macedonian Academy of Sciences, are a good illustration of the attitude upon this problem.

Key players in geothermal development are:

- Ministry of Economy of Republic of Macedonia – Energy Department and Department for Mineral Resources: The Department has no capacity and interest to have active involvement in the geothermal energy development, nor comprehension;
- Energy Agency of Republic of Macedonia: Either young, this institution puts lot of efforts towards creation of enabling conditions for RES use. However, they still cope with employments, capacity building, budget, competences, therefore it cannot be expected their active involvement in geothermal issues in near future.
- Macedonian Geothermal Association (MAGA): NGO, working in geothermal development in the country and worldwide. Even very active and continually present with different initiatives, it is completely neglected by the government, as a general attitude towards NGOs.

Even incomplete, the recuperation of some users resulted with several investments in reconstruction and optimization of existing geothermal projects. These have provoked the interest of the others for similar actions or even new projects, but usually they are stacked in the process of obtaining exploration concession rights. The process is retard due to the list of constraints, mainly in the legal and financial reasons. Existing pressure from WB and EC to put more efforts on environmental protection can have positive influence in overcoming those barriers, but according to the experience, it can be assumed that such process would take at least 4-5 years.

2. GEOLOGY BACKGROUND

2.1 Geological Framework and Tectonic Settings of Macedonia (Micevski, 2003)

In the territory of Macedonia rocks of different age occur, beginning with Precambrian to Quaternary ones. Almost all lithological types are represented. The oldest, Precambrian rocks consist of gneiss, micaschists, marble and orthometamorphites. The rocks of Paleozoic age mostly belong to the type of green schists, and the Mesozoic ones are represented by marble limestones, acid, basic and ultrabasic magmatic rocks. The Tertiary sediments consist of flysch and lacustrine sediments, sandstones, lime-stones, clays and sands.

Figure 1: Geological settings and geothermal regions in Macedonia (Arsovski, 1997).

With respect to the structural relations the territory can be divided into six geotectonic units (Fig. 1): The Cukali-Krasta zone, Western-Macedonian zone, Pelagonian horst-anticlinorium, Vardar zone, Serbo-Macedonian massif and the Kraisthide zone. This tectonic setting is based on actual terrain and geological data without using the geotectonic hypothesis (Arsovski, 1997). First four tectonic units are parts of Dinarides, Serbo-Macedonian mass is part of Rodopes and the Kraisthide zone is part of Karpato-Balkanides distinguished on the Balkan peninsula as geotectonic units of first stage.

2.1 Geothermal Background (Georgieva, 2002)

The territory of the Republic of Macedonia belongs to the Alpine-Himalayan zone, with the Alpine sub-zone having no contemporary volcanic activity. This part starts from Hungary, across Serbia, Macedonia and North Greece and stretches to Turkey. Several geothermal regions have been distinguished including the Macedonian region, which is connected to the Vardar tectonic unit. This region shows positive geothermal anomalies and is hosting different geothermal systems. The hydro-geothermal systems, at the moment, are the only ones worth exploration and exploitation.

There are 18 known geothermal fields in the country (Fig.2) represented with more than 50 thermal springs, boreholes and wells with hot water, having discharge of about 1000 l/s with temperatures between 20-79°C. Hot waters are mostly of hydrocarbonate nature, according to their dominant anion, and mixed with equal presence of Na, Ca and Mg. The dissolved minerals range from 0.5 to 3.7 g/l.

All thermal waters in Macedonia are of meteoric origin. Heat source is the regional heat flow, whose value in the Vardar zone is approximately 100 mW/m^2 and crust thickness is 32 km.

3. GEOTHERMAL RESOURCES AND POTENTIAL

Out of the seven geothermal fields identified in the east and northeast part of the country, four have been found to be very promising and three have been explored to the stage of possible practical use. Except the springs in Debarska banja and Kosovrasti, positioned in the West Bosnian-Serbian-Macedonian geothermal zone, all the others are located in the Central Serbian-Macedonian Geothermal Massif, Central and Eastern Macedonia (Figure 2).

It should be emphasized that the total available flow of the exploitable sources is 922.74 l/s, which is less than the estimated 1000 l/s 7 years ago, and differs from the previous values (1397 l/s) that are the maximum measured short lasting flows. The difference is due to the more precise data for long lasting capacities of all the flows, after many years of exploitation and measurements.

Temperatures of the flows vary in the range of 24-27°C (Gornicet, Volkovo and Rzanovo) up to 70-78°C (Bansko and Dolni Podlog). Total average temperature is 59.77°C. The biggest potential is in the Kocani geothermal field, with a total maximal flow of up to 350 l/s and temperatures of 65°C (Istibanja) and 75-78°C (Dolni Podlog). Next is the Gevgelija geothermal field, with about 200 l/s and temperatures of 50°C (Negorci) and 65°C (Smokvica). The list of the others is: Debar geothermal field with 160 l/s and temperatures of 40°C (Debarska banja) and 48°C (Kosovrasti), Strumica geothermal field with 50 l/s and 70°C and Kratovo/Kumanovo geothermal field with 71 l/s and temperatures of 31°C (Kumanovska banja) and 48°C (Kratovo).

Figure 2: Main geothermal fields in Macedonia (Popovski, 2001).

The real energy potential of the geothermal resource in Macedonia is in direct correlation with the technical/technological feasibility of its application, in accordance to the newest know-how in the country and in the world. A simulation, according to different outlet temperature, is made for all the exploitable geothermal resources in Macedonia. A total available maximum heat power of 173 MW is obtained, which suggests the possibility of annual maximum production of 1.52 TWh/year. This is only a theoretical indication considering that each project has different range of exploited temperature. In any case this maximum potential cannot be fully exploited, since it is strongly dependent on the utilization factor and the type of application. For instance, the geothermal system in Dolni Podlog (Kocani) has a maximum flow of about 300-350 l/s with temperature of 75°C. If a maximal use of the source could be reached (i.e. effluent water of 15°C), its heat power could increase up to 75-85 MW. However, the applied technical solutions by the users result with temperatures of the effluent water of 40-45°C during the (winter) heating season. These in turn decreases the heat power of the source to 37.7-44.0 MW, i.e. 40-50% of the maximally possible one. For the same geothermal system and composition of users, it is technically and economically feasible to obtain lower temperature of the effluent water of 30°C during the first phase of development (Popovski, 1991), and 25°C during the second phase of development. Such optimization would enable reduction of the losses for 25% and 17% respectively, which is in the acceptable limits even for the countries with longer experience in geothermal energy application. Therefore, depending on the achieved average outlet temperature of projects using available geothermal resources, the following orientation figures for total heat power could be taken: 172.9 MW for 15ºC, 153.7 MW for 20ºC, 134.3 MW for 25ºC, 115.6 MW for 30ºC, 97.2 MW for 35ºC, 78.9 MW for 40ºC and 68.2 MW for 45ºC. According to the presently applied solutions, average outlet temperatures between 30 and 40ºC are taken as representative.

4. GEOTHERMAL FIELDS IN MACEDONIA

There are 18 localities where geothermal fields occur and geothermal energy is in use for different proposes. The most known areas are listed below:

- *Kocani valley* (Popovski, 2002): The main characteristics of the Kocani valley geothermal system are: presence of two geothermal fields, Podlog and Istibanja, without hydraulic connection between them. The primary reservoir is build by Precambrian gneiss and Paleozoic carbonated schists, where by drilling the highest measured temperature in Macedonia of 79ºC had been obtained. Predicted maximum reservoir temperature is about 100ºC (Gorgieva, 1989). Kocani geothermal system is the best explored system in Macedonia. There are more than 25 boreholes and wells with depths of 100-1170 m. (Popovski, 2009)
- *Strumica valley* (Popovski, 2002): The main characteristics of this field are: the recharge and discharge zone occur in the same lithological formation - granites; there are springs and boreholes with different temperature at small distances; maximum measured temperature is 73^{o}C; the predicted maximum temperature is 120^{o}C (Gorgieva, 1989); the reservoir in the granites lies under thick Tertiary sediments. Bansko geothermal system has not been examined in detail apart the drilling of several boreholes with depths of 100-600 m. (Gorgieva, 2002)
- *Gevgelija valley* (Popovski, 2002): There are two geothermal fields in the Gevgelija valley: Negorci spa and Smokvica. The discharge zones in both geothermal fields are fault zones in Jurassic diabases and spilites. These two fields are separated by several km and there is no hydraulic connection between them, despite intensive pumping of thermal waters. The maximum temperature is 54ºC, and the predicted reservoir temperature is 75-100ºC (Gorgieva, 1989). Geothermal system in the Gevgelija valley has been well studied by 15 boreholes with depths between 100-800 m. (Gorgieva, 2002).
- *Skopje valley* (Popovski, 2002): There are two geothermal fields in the Skopje valley: Volkovo and Katlanovo spa. There is no hydraulic connection between them. The main characteristics of the Skopje hydro-geothermal system are: maximum measured temperature of 54.4^{o}C and predicted reservoir temperature (by chemical geothermometers) of 80-115^{o}C (Gorgieva, 1989); the primary reservoir is composed of Precambrian and Paleozoic marbles; big masses of travertine deposited during Pliocene and Quaternary period along the valley margins. There are only five boreholes with depths of 86 m in Katlanovo spa, 186 and 350 m in Volkovo and 1654 and 2000 m in the middle part of the valley. The last two boreholes are without geothermal anomaly and thermal waters because of their locations in Tertiary sediments with thickness up to 3.800 m. (Gorgieva, 2002)

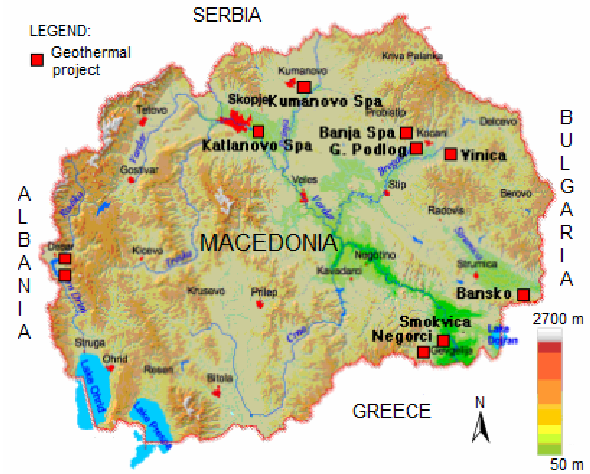

Figure 3: Location of geothermal projects in Macedonia.

5. GEOTHERMAL UTILIZATION

The utilization of thermal waters consists of 7 geothermal projects and 6 spas. All of them had been completed before and during the 1980s. The present state of the projects is as follows:

- *Istibanja (Vinica) Geothermal Project*: Heating of 6 ha greenhouse complex in combination with a heavy oil boiler for peak loadings. It has been one of the worst completed projects before the crisis, however after the privatization in 2000 yr. it has been reconstructed and optimized with Austrian and Dutch grants and now properly covers the heat requirements of the roses' production for export. The owners are interested to continue with explorations in order to enable geothermal heating of additional 6 ha of greenhouses, but so far cannot achieve common interest with the municipality as owner of the concession rights.
- *Kocani (Podlog) Geothermal Project* ("Geoterma"): At present the largest geothermal project in Macedonia, composed of 18 ha greenhouse complex heating, and space heating of public buildings in the center of the town. Due to the economic circumstances, paper industry, vehicle parts industry and rice drying unit have been lost as heat consumers during the last 12 years. Nevertheless, by two Austrian grants, three additional boreholes have been drilled, partial injection of effluent water has been completed and monitoring system has been introduced in the system. Nowadays, there are activities in direction to finalize the completion of the reinjection and connection of public buildings in the center of the town. Project operates as a public and its organizational structure is well covered by the existing team. The only problem in operation is the price of supplied heat, which is kept very low by the State Energy Regulatory Commission, not including the costs of the necessary maintenance, service and development of the system.
- *Bansko Geothermal Project*: The bankruptcy of ZIK "Strumica" and the slow process of its privatization resulted in the collapse of the organizational structure and proper use of the system. Due to increased number of consumers and failure in covering the peak loadings, in order to enable proper operation, it is necessary to introduce centralized managing system and new exploitation boreholes, as well as considerable technical reconstructions and optimizations. Currently the exploitation concession is owned by one company to heat their greenhouses, but due to unsolved energy managing rules there are other consumers, too. Those are the hotel Car Samuil, Spiro Zakov (rest house, rehabilitation facilities for children), other plastic-houses, rest house Jugotutun, rest house ZIK Strumica, experimental and private plastic-houses.
- *Smokvica (Gevgelia) Geothermal System*: Once the largest geothermal system in Macedonia, covering the heating requirements of 22.5 ha glasshouses and of about 10 ha plastic-houses, nowadays is out of operation. At present, only 3 wells out of 7 are exploited with total flow of 90 l/s and temperatures between 63,9-68,5^{o}C, to heat 10 ha greenhouses of which 6 ha glasshouses and 4 ha plastic-houses. When outside temperatures are very low back-up heavy oil boiler is used.
- *Negorci (Gevgelija) Spa*: Reconstruction of the heating installations has been finalized and now all the hotel and therapeutic facilities are heated with geothermal energy. Project is in a process of continual step by step modernization.
- *Other Spas in Macedonia*: Even planned, reconstruction of heating systems and their orientation towards geothermal energy use in Macedonian spas has not been realized due to their undefined property and the absence of funds. Now, when the process is finalized, activities to find possible investors are in progress in Katlanovo Spa, Kezovica Spa and Bansko Spa. However, it is not possible to expect quick results, due to the absence of capital in the country and real interest of foreign investors.

6. CONCLUSIONS

"Energy Development Strategy for Republic of Macedonia up to 2030" and "Strategy for Exploitation of Renewable Energy Sources in Republic of Macedonia up to 2020" do not include any foreseen geothermal development as a prospective energy source for Macedonia. Despite the formal attitude, some private initiatives exist, which will probably influence changes in this sector in the near future. Most important among them are: the renewal of the Smokvica geothermal system, reconstruction and expanding of the Bansko geothermal system and foundation of a new one in Dojran. Final completion of the injection system in Kocani is expected to be realized during the next two-three years. It is also expected that majority of spas would undergo reconstructions with intention to use geothermal energy for heating of the accommodation capacities, but so far there are no such information. Up to now, there is no any progress concerning the very prospective geothermal fields Kratovo-Zletovo, Skopje and Kumanovo regions.

Nevertheless, there are many improvements which should be done with the existing legislation in order to facilitate geothermal explorations and application, to enable sustainable exploitation and consider the environmental issues. Those are: definition of sustainable outflows, rights over single geothermal field, obligation to inject the used geothermal water, treatment of the geothermal water as mineral resource instead as energy resource too, calculation methodology for feasible and motivating price for geothermal heat, creation of subsurface register, incentives etc. (Panov, 2011)

The geothermal development in Macedonia is in stagnation for already 20 years, hopefully the situation will change along with the contemporary energy trends and initiatives in the country.

REFERENCES

Arsovski M. (1997): Tektonika na Makedonija, Stip Dimitrov K., Gorgieva M. and Popovski K.: Geothermal Energy Resources and their Use in the Republic of Macedonia, Proceedings of the World Geothermal Congress 2000 Kyushu – Tohoku, Japan, May 28 –June 10, 2000

Georgieva M.: Summary of Fundamentals for Evaluation of the Geothermal Potential of the Vardarian Zone and Serbian-Macedonian Massif at the Teritorry of the Republic of Macedonia, Annual Workshop of MAGA, Ohrid 2003

Georgieva M., Gorgiev D., Popovski K., Dimitrov K., Manasov S.: Inferred Section of the Main (Low-temperature) Geothermal Systems in the Republic of Macedonia, Proceedings World Geothermal Congress 2000 Kyushu - Tohoku, Japan, May 28 – June 10, 2000

Gorgieva M., Popovski K., Gorgiev D.: Geothermal Energy in Macedonia, State-of-the-Art and Perspectives, International Geothermal Days of ISS “Greece 2002”, Proceedings, Skopje 2002

Micevski E.: Geotermalen potencijal na jugo-zapadniot del na Makedonija, Annual Workshop of MAGA, Ohrid 2003

Popovski K.: Feasibility Study on Possible Investments in Geothermal Projects in Macedonia, WB Study, Skopje 2002

Popovski K.: Geothermal Energy Use in Macedonia, International Conference GEAIA, Athens 2004.

Popovski K., Micevski E., Popovska-Vasilevska S.: Macedonia – Country Update 2004, Proceedings World Geothermal Congress, Antalya, Turkey, 24-27 April 2005

Panov Z., Gulev G., Ilievski A., Analysis of the Regulation for Exploration, Exploitation and Utilization of the Geothermal Water in the Republic of Macedonia, Kocani, 2011

Macedonian Academy of Science and Arts, Energy Development Strategy for Republic of Macedonia for the period 2008-2020 with vision up to 2030, Skopje, 2009

Macedonian Academy of Science and Arts, Strategy for Exploitation of Renewable Energy Sources in Republic of Macedonia up to 2020, Skopje, 2010

Tables A-G

Table A: Present and planned geothermal power plants, total numbers*

*Geothermal power plants are not available in the country.

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants are not available in the country.

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers

	Geothermal DH Plants		Geothermal heat in agriculture and industry		Geothermal heat in balneology and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2012	42.55*	144.00	2,79	17.00	0.84**	1.83
Under construction end of 2012	0	0	0	0	0	0
Total projected by 2015	NA		NA		NA	

*98,6% of the produced heat used for heating greenhouses; ** available data for one spa; NA-data not available

Table D: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commiss.	Is the heat from geothermal CHP?	Is cooling provided from geothermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geothermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Bansko	Bansko		No	No	8.65	8.65	NA	100%
Kocani	Zelena kuka		No	No	33.90	33.90	NA	100%
total					**42.55**	**42.55**	**NA**	**100%**

NA-data not available

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012	> 150	NA	NA	NA	NA	NA
Projected by 2015	NA	NA	NA			

NA-data not available

Table F: Investment and Employment in geothermal energy

	in 2012		Expected in 2015	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power	0	0	0	0
Geothermal direct uses	0	0	0	0
Shallow geothermal	NA	NA	NA	NA
total				

NA-data not available

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	EU, bilateral funds	EU, bilateral funds	EU, bilateral funds
Financial Incentives – Investment	No	LIL	LIL
Financial Incentives – Operation/Production	No	No	No
Information activities – promotion for the public	No	Yes	Yes
Information activities – geological information	Yes	Yes	No
Education/Training – Academic	Treated as a part of the subject Power Generation from RES	Treated as a part of the subject RES	Treated in frame of the subject Heat Pumps
Education/Training – Vocational	No	Yes	Yes

Key for financial incentives:

DIS	Direct investment support	RC	Risk coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota